Rotary electric machine with permanent-magnet rotor

The present invention relates to rotary electric machines with permanent-magnet rotors.

An object of the present invention is to provide a rotary electric machine, in particular a direct-current motor which can be used for example in electric household appliances, having a structure which is extremely simple and can be produced at a very low cost.

This object, together with others, is achieved according to the invention by a rotary electric machine comprising:

a rotor with at least one permanent magnet, for producing a uniform annular distribution of magnetic polarities of angularly alternating sign about the axis of rotation of the rotor, within a magnetized surface lying in a plane essentially perpendicular to said axis, and

a stator including:

a flow-conveying structure formed with a pressure-shaped mass of insulated ferromagnetic particles; said structure having a base portion from which first and second arms extend substantially parallel to the axis of the rotor, said arms being situated essentially at a first and a second radial distance, respectively, from said axis and angularly alternating with respect to each other; the ends of said first and second arms opposite to said base portion frontally facing said magnetized surface of the rotor from which they are separated by an air-gap; and

a winding arranged coaxially with the rotor, in an annular region lying between said first and second arms of the flow-conveying structure.

Further characteristic features and advantages of the invention will emerge from the following detailed description

provided purely by way of a non-limiting example with reference to the accompanying drawings in which:

Figure 1 is a side view of an electric motor designed in accordance with the present invention;

Figure 2 is a cross-sectional view along the line II-II in Figure 1;

Figure 3 is a perspective cross-sectional view of the electric motor according to Figures 1 and 2;

Figure 4 is a top plan view of part of the stator of the motor according to the preceding figures;

Figure 5 is a cross-sectional view along the line V-V in Figure 4;

Figure 6 is a top plan view of a flow-conveying structure included in a motor according to the invention;

Figure 7 is a cross-sectional view along the line VII-VII in Figure 6;

Figure 8 is a side view in the direction of the arrow VIII in Figure 6;

Figure 9 is a perspective view of the flow-conveying structure according to Figures 6 to 8;

Figure 10 is a bottom plan view of a bobbin for a winding of the electric motor according to the preceding figures;

Figure 11 is a view, on a larger scale, of a detail indicated by the arrow XI in Figure 10;

Figure 12 is a cross-sectional view along the line XII-XII in Figure 10;

Figure 13 is a view, on a large scale, of a detail indicated by XIII in Figure 12;

Figure 14 is a plan view of a printed-circuit board for the control components of a motor according to the preceding figures; and

Figure 15 is a perspective view of a permanent magnet for the rotor of a motor according to the preceding figures.

With reference to the drawings and in particular Figures 1 to 3, 1 denotes overall en electric motor designed in accordance with the present invention.

Although the description below refers to an embodiment of the electric machine according to the invention intended to operate as a motor, as is obvious for persons skilled in the art the description below is applicable, *mutatis mutandis*, to an embodiment of an electric machine according to the invention intended to operate as a generator.

With reference now to Figures 1 to 3, the motor 1 shown there is in particular a direct-current motor comprising a rotor denoted overall by 2 and a stator denoted overall by 3.

In the embodiment shown by way of example, the rotor 2 comprises a support body 4 essentially in the form of an overturned cup, to the end wall 4a of which an annular shaped permanent magnet 5 is fixed.

The rotor 2 also comprises a shaft 6 having one end 6a fixed coaxially inside the body 4 of the rotor. The shaft 6 is in particular mounted in a projecting manner in the central portion of the end wall 4a of said body 4.

The stator 3 comprises a supporting structure which is denoted overall by 7 in Figures 2 and 3. This structure, which like the body 4 of the rotor may be made for example of moulded plastic, essentially comprises an end portion 8 from one side of which a stem portion denoted overall by 9 extends centrally (see also Figures 4 and 5).

In the embodiment shown, on the side directed towards the body 4 of the rotor, the end 8 of the supporting structure 7 of the stator has two coaxial annular shaped elements 8a, 8b,

between which a groove 10 is defined, inside which groove the bottom terminal edge of the body 4 of the rotor extends with radial play.

The stem-like portion 9 of the supporting structure 7 of the stator comprises a cylindrical, tubular, inner wall 11 around which a further near-cylindrical wall 12 extends coaxially. In fact, the wall 12 forms a recess, denoted by 13 in Figure 4, having an angular extension which in the example illustrated is nearly 90°. This recess extends substantially over the whole length of the wall 12, as can be understood by considering Figure 4 in conjunction, for example, with Figure 5.

As can be seen in Figures 2 and 3, the shaft 6 of the rotor 2 extends coaxially on the inside of the tubular wall 11 of the supporting structure 7 of the stator and is rotationally supported there for example by means of two bushes 14 and 15.

A flow-conveying structure, denoted overall by 16 in Figures 2, 3 and 6 to 9, is mounted on the portion 9 of the supporting structure 7 of the stator 3.

The flow-conveying structure 16 is conveniently formed as one piece with a pressure-shaped mass of insulated ferromagnetic particles. This structure 16 has in particular a base portion 17 which, in the example shown, is essentially in the form of a planar ring, from one side of which two sets of lugs or arms extend upwards, substantially parallel to the axis A-A of the rotor and denoted by 18 and 19, respectively.

The base part 17 could also not necessarily be planar, but have the shape of a cup with an opening in its end wall.

As can be seen in particular in Figure 6, the arms 18 are more towards the outside, being situated at a same radial distance from the axis A-A, than the arms 19 which are instead situated at a same and smaller radial distance from this axis.

In the embodiment shown, the flow-conveying structure 16 has four radially outermost arms 18 which are angularly equidistant and extend by the same amount and four radially innermost arms 19 which are also angularly equidistant and extend by the same amount.

As mentioned further above, the base part 17 of the flow-conveying structure 16 conveniently has an annular shape and the arms 18 extend flush with its external circumference, while the arms 19 extend essentially flush with the edge of its internal circular opening 20.

As can be seen more clearly in Figure 6, the inner arms 19 of the flow-conveying structure 16 are situated angularly alternating with the radially outermost arms 18.

Conveniently the arms 18 and 19 have substantially the same cross-sectional area.

The arms 18 and 19 may have a certain degree of angular overlap at their outer ends and the latter may also be suitably tapered and/or jointed so as to reduce the so-called "cogging torque".

The terminal surfaces 18a and 19a of the arms 18 and 19 of the structure 16, opposite to the base part 17, are situated frontally facing the surface 5a of the permanent magnet 5 of the rotor (Figures 2 and 3).

An air-gap 21 is defined between the terminal surfaces 18a and 19a of the arms 18 and 19 of the flow-conveying structure 16 of the stator and the flat annular surface 5a of the permanent magnet 5 (Figures 2 and 3).

An annular region, inside which a bobbin 22 which supports a winding 23 of insulated electric wire is arranged, is defined between the radially outer arms 18 and the radially inner arms 19 in the flow-conveying structure 16. This bobbin is shown in particular in Figures 10 to 13 and comprises an intermediate tubular portion 22a provided with two annular end flanges 22b and 22c (Figures 10 and 12).

Conveniently the terminal surfaces 18a, 19a of the arms 18, 19 do not lie in a same transverse plane, but are slightly inclined, all in the same direction, as can be seen in particular in Figures 7 and 8. This results in an air-gap of cyclically variable amplitude and the possibility of determining a predefined angular rest position for the rotor 2 and ensuring the generation of a torque of predetermined magnitude upon start-up.

As can be seen in particular in Figure 10, the flanges 22b and 22c of the bobbin 22 have a shaped peripheral profile so that they are capable of engaging in the annular region between the outer arms 18 and the inner arms 19 of the flow-conveying structure 16. In particular, these flanges each have four radially projecting lugs 24 which are angularly equidistant and extend by the same amount and which engage in the interspaces between pairs of adjacent arms 18 of the flow-conveying structure 16.

With reference to Figure 12, respective studs 25 extend centrally from the radially projecting lugs 24 of the bottom flange 22c of the bobbin 22 (see also Figures 10, 11 and 13).

These studs 25 are parallel to each other and, in the assembled condition of the bobbin, extend through corresponding peripheral incisions 26 in the base part 17 of the flow-conveying structure 16 (see Figures 6 to 9).

The studs 25 have respective axial channels 27. The terminals of the winding 23 mounted on the bobbin 22 extend through the channels 27 of at least one pair of these studs. The studs 25 of the bobbin terminate in respective tapered elements 28 which engage through corresponding openings 29 of a printed circuit board 30 of essentially annular shape which extends around the stem portion 9 of the supporting structure 7 of the stator (Figures 2, 3 and 14).

In a manner not shown, the printed circuit board 30 houses components of circuits controlling the electric motor 1.

The lugs 28 of the studs 25 of the bobbin 22 extend through and beyond the openings 29 of the printed circuit board 30 and are fixed to this board, for example by means of hot-heading.

The terminals of the winding 23 mounted on the bobbin 22 pass through the channels 27 defined inside the studs 25 integral with said bobbin and are connected, for example by means of soldering, to the printed circuits housed on the board 30.

As can be seen in particular in Figure 14, the board 30 has a lug 31 which extends radially from its inner edge, towards the axis A-A of the rotor. This lug 31 is positioned inside the lateral recess 13 of the stem-like part 9 of the supporting structure 7 of the stator.

In the embodiment shown by way of example, the lug 31 of the board 30 is provided with an eyelet 32 inside which a support

plate 33 of elongated shape is fixed (Figure 2), said plate extending parallel to the axis of the motor as far as the inside of the cavity of the annular permanent magnet 5. The end of the plate 33 facing the magnet 5 is provided with a sensor 34, for example of the Hall type. During operation, this sensor allows detection of the angular position of the rotor.

The plate 33 also has tracks for connecting the sensor 34 to the other components of the circuits housed on the printed circuit board 30.

Figure 15 shows one constructional form of the permanent magnet 5. This magnet is designed so that, at least on its flat side 5a facing the stator, it has a uniform distribution of magnetic poles N, S arranged angularly alternating about the axis of rotation of the rotor.

Preferably the number of magnetic poles produced by the magnet 5 on its surface 5a is equal to the overall number of outer arms 18 and inner arms 19 of the flow-conveying structure 16.

The arrangement is such in this case that, when the radially outermost arms 18 of the flow-conveying structure 16 with their end surfaces 18a face portions or segments of the permanent magnet 5 having the polarity N, the radially innermost arms 19 of said structure 16 with their end surfaces 19a face portions or segments of the magnet having a polarity S.

As can be understood from the above description, the present invention allows the design of rotary electric machines with an extremely simple and compact structure and with an extremely small number of parts. These machines can therefore

be manufactured at a very low cost.

The invention may also be used for the production of direct-current or alternating-current electric motors as well as generators.

Without obviously modifying the principle of the invention, the embodiments and the constructional details may be greatly varied with respect to that described and illustrated purely by way of a non-limiting example, without thereby departing from the scope of the invention, as defined in the accompanying claims.